

## PATENT COOPERATION TREATY

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## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

## (PCT Article 36 and Rule 70)

Applicant's or agent's file reference 15930PCT00	<b>FOR FURTHER ACTION</b>	
	See Form PCT/IPEA/416	
International application No. PCT/DK2004/000705	International filing date (day/month/year) 14.10.2004	Priority date (day/month/year) 14.10.2003
International Patent Classification (IPC) or national classification and IPC F03B13/18, F03B11/06, F16C27/06		
Applicant WAVE STAR ENERGY APS		

<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> <i>(sent to the applicant and to the International Bureau) a total of 4 sheets, as follows:</i></p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</li> <li><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</li> </ul> <p>b. <input type="checkbox"/> <i>(sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</i></p>
<p>4. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Box No. I Basis of the opinion</li> <li><input type="checkbox"/> Box No. II Priority</li> <li><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li><input type="checkbox"/> Box No. IV Lack of unity of invention</li> <li><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li><input type="checkbox"/> Box No. VI Certain documents cited</li> <li><input type="checkbox"/> Box No. VII Certain defects in the international application</li> <li><input type="checkbox"/> Box No. VIII Certain observations on the international application</li> </ul>

Date of submission of the demand 02.05.2005	Date of completion of this report 22.12.2005
Name and mailing address of the international preliminary examining authority:   European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer  O'Shea, G Telephone No. +31 70 340-4424



**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000705

**Box No. I Basis of the report**

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
  - This report is based on translations from the original language into the following language, which is the language of a translation furnished for the purposes of:
    - international search (under Rules 12.3 and 23.1(b))
    - publication of the international application (under Rule 12.4)
    - international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

**Description, Pages**

1-21 as originally filed

**Claims, Numbers**

1-28 filed with telefax on 02.05.2005

**Drawings, Sheets**

1/23-23/23 as originally filed

a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3.  The amendments have resulted in the cancellation of:

the description, pages  
 the claims, Nos. 29,30  
 the drawings, sheets/figs  
 the sequence listing (*specify*):  
 any table(s) related to sequence listing (*specify*):

4.  This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

the description, pages  
 the claims, Nos.  
 the drawings, sheets/figs  
 the sequence listing (*specify*):  
 any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

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**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000705

**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes: Claims	1-28
	No: Claims	
Inventive step (IS)	Yes: Claims	1-28
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-28
	No: Claims	

**2. Citations and explanations (Rule 70.7):**

**see separate sheet**

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**Re Item V**

**Reasoned statement with regard to novelty, inventive step or industrial applicability;  
citations and explanations supporting such statement**

1. Reference is made to the following documents:

D1: WO 89/07197 A (BURTON, LAWRENCE, C) 10 August 1989

D2: US-A-5 986 349 (EBERLE ET AL) 16 November 1999

2. The document D1 is regarded as being the closest prior art to the subject-matter of

claim 1, and shows (the references in parentheses applying to this document):

A wave power apparatus (see figures 1 and 2) comprising:

at least one arm (46,48) which is rotationally supported at one end by a shaft (40) and carrying a float (54) at its other end, which is opposite to the supported end; power conversion means (42)(see page 5, lines 10-16) for converting power transmitted from the waves to the arms into electric power; a hydraulic lifting system for lifting the float out of the ocean (see page 8, line 30 - page 9, line 20) and for locking the float in an upper position above the ocean surface.

The subject-matter of claim 1 differs from this known wave power apparatus in that there are plurality of arms, each of which is connected via actuators to the hydraulic driving system, which is adapted to individually lift each float out of the water.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as optimising the power output of the wave power apparatus during abnormal conditions of operation.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

Each of the plurality of arms is connected to one or more common (mutual) motors which are driven by the hydraulic medium from common hydraulic conduits. This results in smaller fluctuations of power output than if the movement of each arm were

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(SEPARATE SHEET)**

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to feed into a separate motor. In the apparatus of the present invention, the common hydraulic motor may continue to operate without major fluctuations in power output even when an arm is lifted out of the water (e.g. for maintenance or when the wind from a certain direction is too strong). In the case of the device disclosed in D1, as there is only one float coupled to one motor, the entire system would have to be shut down in the event of the float being lifted out of the water. D1 therefore contains no teachings about lifting one of a plurality of floats out of the water. Although the device of D2 discloses a plurality of floats, there are no teachings about lifting these floats entirely out of the water. Hence the skilled person is not presented with teachings which, without the benefit of hindsight, would prompt him to modify the device of D1 thereby arriving at wave power apparatus according to claim 1 of the present invention.

3. Claims 2-28 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

## CLAIMS OF 2 MAY 2005 - FAIR VERSION

International application No.: PCT/DK2004/000705

Applicant: WAVE STAR ENERGY APS

## 5 CLAIMS

## 1. A wave power apparatus comprising:

- at least one arm, which is rotationally supported at one end by a shaft and carrying a float at its other end, which is opposite to the supported end, so that a translational movement of the float caused by a wave results in rotation of the arm around the shaft,
- 10 - power conversion means for converting power transmitted from the wave to the at least one arm into electric power by means of a hydraulic driving system with at least one hydraulically driven motor, and
- a hydraulic lifting system for lifting the float out of the ocean and for locking the float in an upper position above the ocean surface,

15 characterised in that

- said at least one arm comprises a plurality of rotationally supported arms, each of which carries a float,
- each arm being connected to the hydraulic driving system by means of at least one actuator which causes a hydraulic medium of the hydraulic driving system to be displaced 20 into one or more mutual motors, the actuators being arranged to displace the hydraulic medium to the motor(s) via common hydraulic conduits, and
- the hydraulic lifting system is adapted to individually lift each float out of the ocean.

## 2. A wave power apparatus according to claim 1, wherein the float is pivotally joined to the 25 arm.

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3. A wave power apparatus according to claim 1 or 2, comprising a plurality of arms, each arm being supported by at least two bearings which are arranged along a common centre axis, which is coincident with an axis of rotation of the arm, the bearings being offset from the centre axis, so as to counteract radial and axial forces.

## 30 4. A wave power apparatus according to claim 3, wherein the bearings are pre-stressed in an axial direction.

5. A wave power apparatus according to claim 3 or 4, wherein each of the bearings comprises an inner and an outer ring or cylinder, the inner ring being secured to a rotational shaft of the arm, and the outer ring being secured to a fixed support, the bearing further comprising a flexible material between the inner and the outer ring.

5 6. A wave power apparatus according to claim 5, wherein the flexible material comprises at least one cavity or perforation.

7. A wave power apparatus according to claim 5 or 6, wherein the flexible material comprises at least one spring member, such as a flat spring.

8. A wave power apparatus according to any of the preceding claims, wherein the at least 10 one arm comprises a plurality of arms which are arranged in a row such that a wave passing the row of arms causes the arms to successively pivot around the shaft, the arms being arranged at mutual distances, so that at all times at least two of the arms simultaneously deliver a power contribute to the power conversion means, the power conversion means comprising a hydraulic actuator associated with each arm, the hydraulic actuators feeding a 15 hydraulic medium into at least one hydraulic motor via common hydraulic conduits.

9. A wave power apparatus according to claim 8, wherein the row of arms is oriented such with respect to the wave heading that the row forms an angle of within +/- 60° with respect to the heading.

10. A wave power apparatus according to claim 8 or 9, wherein each of the arms 20 intermittently transmits power to the power conversion means when a wave passes the float of the arm, the arms and floats being arranged with such mutual distances that, at all times, at least two arms and floats simultaneously deliver a power contribute to the power conversion means.

11. A wave power apparatus according to any of the preceding claims, wherein buoyancy of 25 the float is at least 10 times its dry weight.

12. A wave power apparatus according to any of the preceding claims, wherein the diameter of the float is at least 5 times its height.

13. A wave power apparatus according to any of the preceding claims, wherein the plurality of arms comprises at least five arms per wavelength of waves.

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14. A wave power apparatus according to any of the preceding claims, wherein the plurality of arms comprises at least five arms spanning over a total length of 50 – 200 m.
15. A wave power apparatus according to any of the preceding claims, wherein the arms and the floats are made from a material which has a density of at most 1000 kg/m<sup>3</sup>.
- 5 16. A wave power apparatus according to any of the preceding claims, wherein the at least one actuator of each arm comprises a double-acting cylinder.
17. A wave power apparatus according to claim 16, wherein the double-acting cylinder forms part of the hydraulic lifting system, so that the cylinder is controllable to lift the float out of the ocean.
- 10 18. A wave power apparatus according to claim 16 or 17, wherein the hydraulic driving system comprises at least one hydraulic accumulator for intermittently storing energy in the hydraulic driving system, and wherein the hydraulic driving system is controllable to release the energy stored in the accumulator, when a float is passed by a wave trough, so as to force the float carried by the arm into the wave.
- 15 19. A wave power apparatus according to claim 18, wherein the hydraulic medium is fed to the hydraulic accumulator system via the common hydraulic conduits.
- 20 20. A wave power apparatus according to any of claims 16-20, wherein each cylinder is provided with a sensor for determining a position and/or rate of movement of the cylinder's piston, the sensor being arranged to transmit a signal to a control unit of the cylinders and associated valves, so that the transmission of energy from the individual cylinders to the remaining parts of the hydraulic driving system is individually controllable in response to the signal representing the individual cylinder's piston's position and/or rate of movement.
- 25 21. A wave power apparatus according to any of the preceding claims, wherein the shaft and the power conversion means are supported by a supporting structure which is anchored to the sea floor by means of a suction anchor.

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22. A wave power apparatus according to claim 21, wherein the supporting structure is anchored to the sea floor by means of a suction anchor and/or a gravitational support.
- 30 23. A power apparatus according to claim 21 or 22, wherein the supporting structure comprises a truss structure, and wherein the suction anchor is arranged in a first nodal point of the truss structure.

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24. A wave power apparatus according to claim 23, wherein the supporting structure comprises a truss structure, and wherein the at least one arm is supported by the truss structure in a second nodal point thereof.

25. A wave power apparatus according to claim 24, wherein said second nodal point is arranged at a summit of a triangular substructure of the truss structure, and wherein the triangular substructure defines two vertices at the sea floor, with an anchor in each of the corners.

26. A wave power apparatus according to claim 25, wherein the truss structure comprises a polygonal substructure, preferably a rectangular substructure, arranged above the triangular substructure.

27. A wave power apparatus according to any of claims 21-26, wherein the supporting structure comprises a ballast for providing a downward force on the supporting structure, the ballast being arranged above sea level.

28. A wave power apparatus according to claim 27, wherein the ballast comprises at least one ballast tank or ballast container.

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